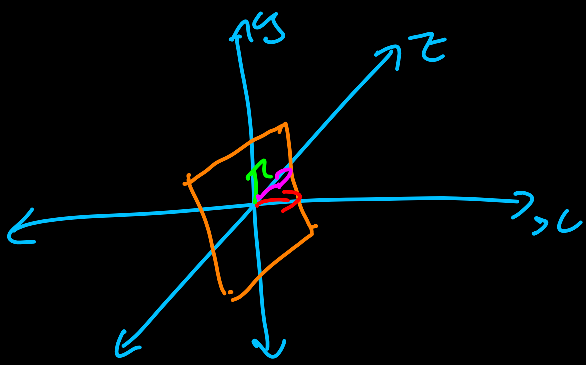
Portal Theory & Implementation

Two portals will be transformed versions of the plane with vertices

$(0,1,1), (0,-1,1), (0,1,-1) (0,-1,-1)$



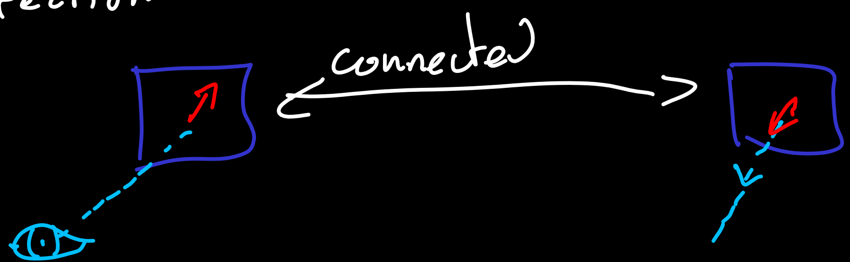
with attached direction vectors

forward $(1,0,0)$

up $(0,1,0)$

right $(0,0,1)$

Two portals can be connected via the "connect-portals" method. In this case, looking at the portal in the direction of the forward vector will be like looking out of the connected portal in the same relative direction.



Implementation

When rendering a portal, we take the current view (camera) and projection matrices and apply some transform to get a new pair of (view, proj) matrices. We use these to render the scene to a framebuffer, then attach that framebuffer to the portal-plane as a texture. We will look more in detail at these transformations:

Camera

A camera (view) matrix is generated from the following pieces of information:

- position
- look-direction
- up

i.e. a coordinate system, translated & rotated relative to i, j, k / (0,0,0) as the basis & origin, respectively. Fortunately, we already provide this in the model-matrix of the portal! We only need the model matrices of both the from & to portal-planes.

This gives a simple two-step process.

- First, apply the <u>inverse</u> of the "from-portal's transform matrix.
- Then, apply the transform matrix of the "to-portal" to get the final position.

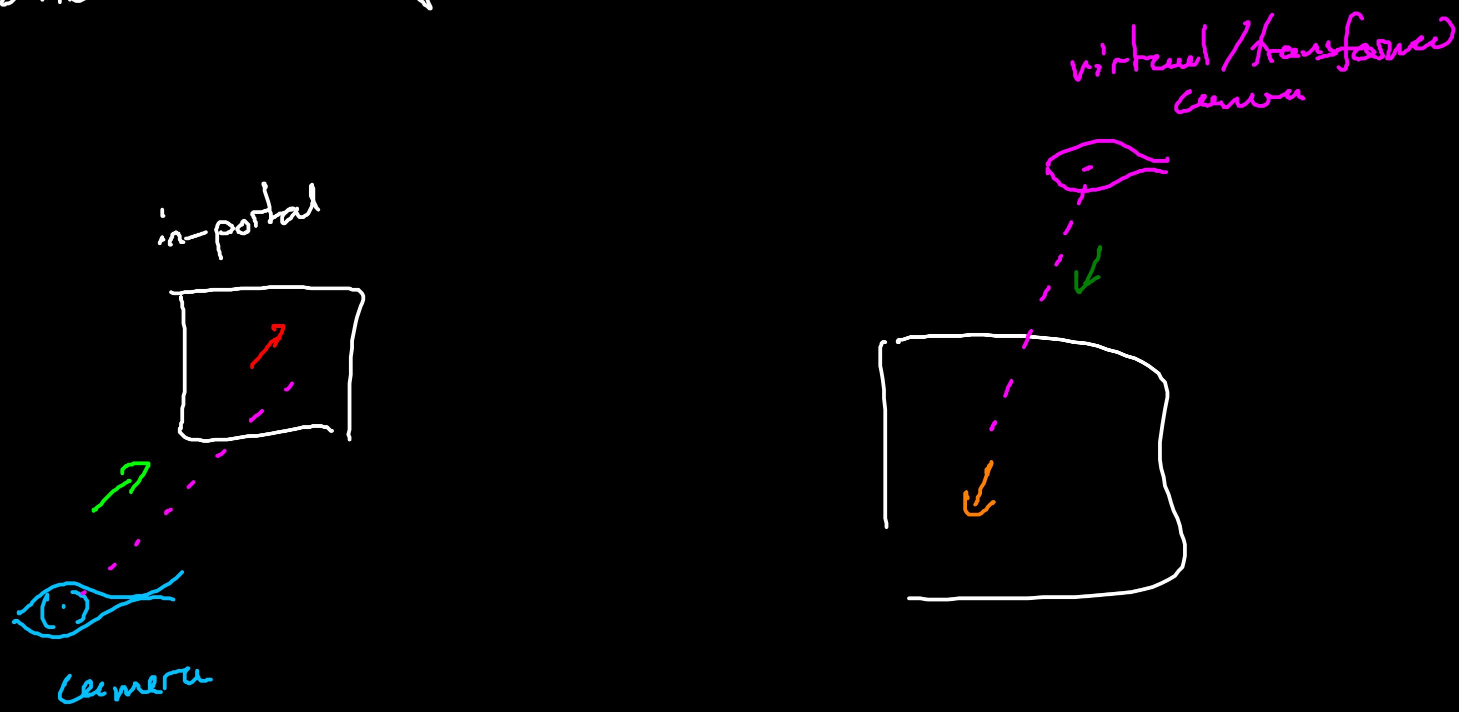
Now, we need only two more pieces of data:

- up
- forward

(right via graham-schmidt)

As a simplifying assumption, let up = (0, 1, 0)

Finally, we need the <u>forward vector</u>. This vector will be <u>parallel</u> to the forward vector of the to-portal. We only need to know if it is pointing in the same or opposite direction as this forward vector. Fortunately, the solution is simple.



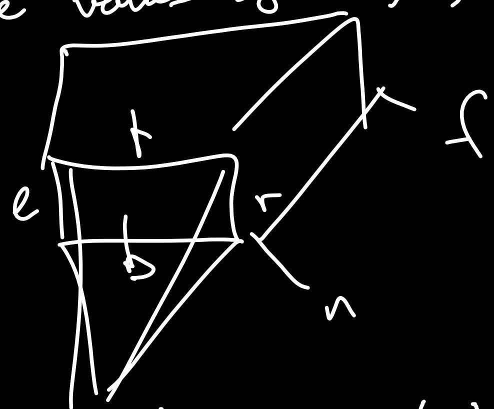
We require that the <u>sign</u> of the dot-product of the camera's look-direction (green) and the from-portal's forward (red) is the same as the virtual / transformed camera's forward (dark green) and the to-portal's forward (orange). Hence, we simply dot, check the sign and choose whether or not to revert the to-portal's forward.

View Matrix

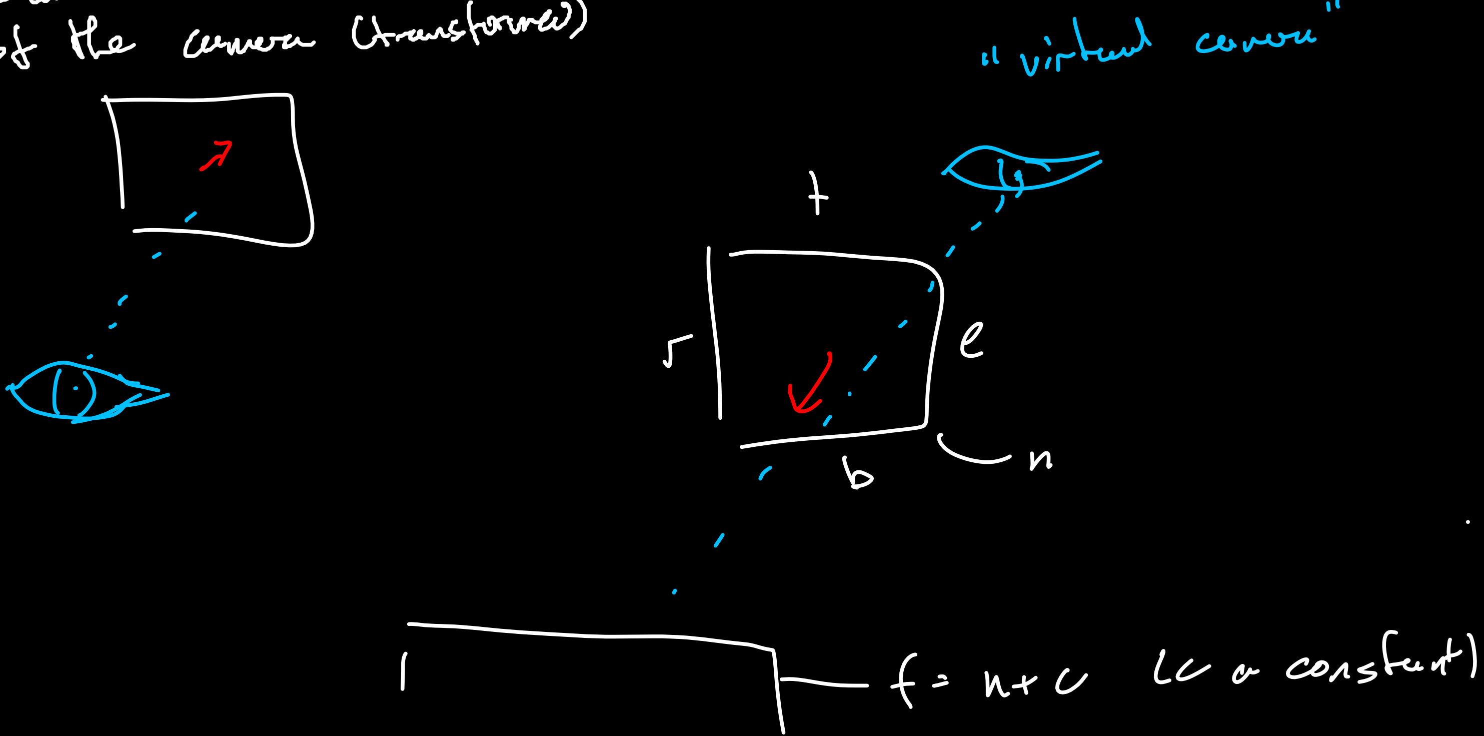
Recall the projection matrix:

$$\begin{bmatrix} \frac{2n}{r-l} & 0 & 0 & 0 \\ 0 & \frac{2n}{t-b} & \frac{t+b}{t-b} & 0 \\ 0 & 0 & \frac{n+f}{n-f} & \frac{2fn}{n-f} \\ 0 & 0 & -1 & 0 \end{bmatrix}$$

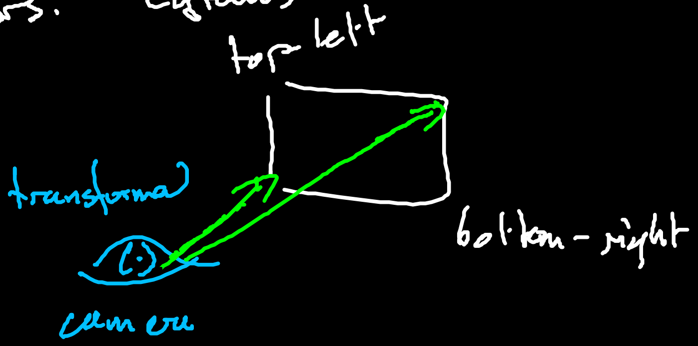
so, we need the values of n, f, l, r, t, b, whr



Fortunately, these values have an obvious source: we consider the top, left, etc. of the portal-plane of the portal-to relative to the transformed camera in the coordinate system of the camera (transformed)



This can be done by taking a dot-product of the vectors: (green)



with the transformed camera's forward, left & right vectors (which will be the same as the to-portal's basis vectors).